Economics Bulletin

Volume 35, Issue 2

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Citation: Arnaud Chéron and Pierre-jean Messe and Jerome Ronchetti, (2015) "Employer-provided health insurance and equilibrium wages with two-sided heterogeneity", *Economics Bulletin*, Volume 35, Issue 2, pages 1109-1117
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Submitted: December 18, 2014. **Published:** May 14, 2015.

Economics Bulletin

Submission Number: EB-14-01033

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1 Introduction

How does health insurance interact with the labor market and especially wages? This issue is obviously not new, and has already given to interesting developments in the literature. At the start, most studies were mainly empirically-oriented and related to the United States experience (see for instance Gruber and Madrian (2002) for a survey). A distinctive feature of the US is indeed that health insurance is available almost exclusively through the workplace.[1] On the theoretical side, potential impacts on wages and job mobility were basically examined by referring to compensating differential models *à la* Rosen (1986) with competitive labor market. This notably suggests that health insurance leads to lower wages for those that value that insurance (Summers, 1989; Gruber and Krueger, 1990), and some job lock can arise when heterogeneity of health insurance packages makes job switching unattractive.[2] Then, following Dey et Flinn (2005), a recent strand of the literature has grown to assess general equilibrium effects of health insurance, in the context of a labor market with search frictions. This approach is particularly well suited to look at the quantitative implications of some reforms of the health care system, as for instance proposed by Aizawa and Fang (2013) who focus on the *Affordable Care Act* in the US.

As regards to this existing literature, our paper aims to develop a more stylized equilibrium search model with both firms' and workers' heterogeneity. The firm has an imperfect information on the health status of the job seekers, which may imply some adverse selection. This two-sided heterogeneity implies that wages and health expenditures policies - which are designed to address this adverse selection issue - depend on the firm's type. Our goal is therefore to derive an analytical characterization of the model properties, as a way to identify the key factors explaining the relationship between firm's type and health expenditure. We therefore highlight that this relationship turns out to be ambiguous. To show this result, we first look at employer's wage and health insurance policies of the firm, then introduce labor supply decision through endogenous reservation wages and lastly determine the search equilibrium.

2 Model environment and employer's behavior

The continuous time model is featured by heterogenous employers according to productivity ϵ, who choose a wage posting policy w for the job (one job is one firm). ϵ belongs to $[\underline{\epsilon}, \overline{\epsilon}]$ and we define $G(\epsilon)$ the distribution function of firms' types. Workers also differ regarding their health endowment y, that determines the overall productivity of the job-worker pair $\epsilon + y$. For a sake of simplicity, we consider two types of workers, the healthy workers with health status denoted by y_h and unhealthy workers with health status $y_l < y_h$.[3] The point is that this health endowment is not observed by the employers, but the latter can choose to *ex-ante* invest in health with intensity $c = c(\epsilon)$. If the worker is healthy, health expenditures have no impact on productivity, whereas if the worker is unhealthy, health investment

[1] As emphasized by Aizawa and Fang (2013), it is the case for 90% of the workers.

[2] See Madrian (1994) for a seminal paper.

[3] We will discuss in the end of the paper the potential implications of considering a continuum of health status rather than only two.

allows them to improve their health status from y_l to y_h during the period with a probability $\mu(c)$.[4] We set $\mu(c) \equiv 1 - \exp(-\gamma c)$ that satisfies $\mu \in [0,1]$ and $\mu' > 0$, $\mu'' < 0$ with $\gamma > 0$ and we only consider steady-state. Let α denote the share of workers in good health, which corresponds to the probability that firm's employee is healthy. We denote by δ the exogenous job's destruction rate. We do not consider on-the-job search. For each job with productivity ϵ the employer decides what package $(w(\epsilon), c(\epsilon))$ to offer. Labor supply decision of the workers determines reservation wages, but as a preliminary step we first consider two exogenous wages according to worker's type, $w_h > w_l$.

The problem of the firm is to maximize the intertemporal value of the job, $\Pi(\epsilon)$, by choosing c and w. This value function satisfies:

$$\Pi(\epsilon) = \begin{cases} \alpha\Pi_h(\epsilon) + (1-\alpha)\Pi_l(\epsilon) & \text{if } w \geq w_h \\ \Pi_l(\epsilon) & \text{if } w \in [w_l, w_h[\end{cases}$$

where:

$$\begin{aligned} r\Pi_h(\epsilon) &= \epsilon y_h - w(\epsilon) - c - \delta\Pi_h(\epsilon) \\ r\Pi_l(\epsilon) &= \epsilon\left[\mu(c)y_h + (1-\mu(c))y_l\right] - w - c - \delta\Pi_l(\epsilon) \end{aligned}$$

This shows that if the employer sets a wage below the reservation wage of workers in good health, then he knows with certainty that the employee will be unhealthy; in such a case, health expenditures c could help increase productivity from y_l to y_h with probability $\mu(c)$. Otherwise, that is for $w \geq w_h$, worker's type is unknown. So health expenditures have no incidence on productivity if the worker is in good health (with probability α).

Accordingly, the value of the job rewrites as follows:

$$(r+\delta)\Pi(\epsilon) = \begin{cases} \epsilon\left[\alpha y_h + (1-\alpha)\mu(c)y_h + (1-\alpha)(1-\mu(c))y_l\right] - w - c & \text{if } w \geq w_h \\ \epsilon\left[\mu(c)y_h + (1-\mu(c))y_l\right] - w - c & \text{if } w \in [w_l, w_h[\end{cases}$$

and the optimization problem of the firm is to $\max \Pi(\epsilon)_{\{c,w\}}$.

On the one hand, it is straightforward to see that the wage policy of the firm is characterized by a productivity threshold $\tilde{\epsilon}$ so that $w(\epsilon) = w_h \;\; \forall\epsilon \geq \tilde{\epsilon}$ and $w(\epsilon) = w_l \;\; \forall\epsilon < \tilde{\epsilon}$. This means that at this stage, firms have to choose between two reservation wages, because for instance paying more than w_h would not allow to improve intertemporal productivity of the job.[5] The threshold $\tilde{\epsilon}$ satisfies the condition $\alpha\Pi_h(\tilde{\epsilon}|w = w_h) + (1-\alpha)\Pi_l(\tilde{\epsilon}|w = w_h) = \Pi_l(\tilde{\epsilon}|w = w_l)$, where $\Pi_l(\tilde{\epsilon}|w = w_h)$ defines the value of the job occupied by an unhealthy worker that earns the highest wage w_h. This implies:

$$\frac{\tilde{\epsilon}\left[\alpha y_h + (1-\alpha)\mu(\tilde{c})y_h + (1-\alpha)(1-\mu(\tilde{c}))y_l\right] - w_h - \tilde{c}}{r+\delta} = \frac{\tilde{\epsilon}\left[\mu(\tilde{c})y_h + (1-\mu(\tilde{c}))y_l\right] - w_l - \tilde{c}}{r+\delta}$$

[4] In other words, we consider that health expenditures of the firms have only transitory effect on the worker's health status. Considering persistence adds complexity that no longer allows to derive closed form solutions and analytical results.

[5] The fact that distribution of wages collapses to the distribution of reservation wages of unemployed workers is a well known result in a context where there is no "on-the-job" search.

where $\tilde{c} \equiv c(\tilde{\epsilon})$, and it can be rewritten as follows:

$$\alpha\tilde{\epsilon} = \left(\frac{w_h - w_l}{y_h - y_l}\right)\frac{1}{1-\mu(\tilde{c})} \tag{1}$$

Equation (1) has several implications. First, $\tilde{\epsilon}$ is increasing with μ. Indeed, if firm's health expenditures have a high incidence on the productivity of unhealthy workers, the employer has less need to attract healthy workers. Consequently, the probability of offering a high wage is lower. Second, $\tilde{\epsilon}$ is positively related to the level of health investment $c(\epsilon)$. A high amount of health expenditures allows the firm to improve the productivity of unhealthy workers, overcoming therefore the adverse selection problem.[6]

On the other hand, the condition that determines health expenditures shows that c depends on firm's type, and hence on related wage policy. First order condition with respect to c indeed implies:

$$1 + \frac{\partial w}{\partial c} = \mu'(c)\left\{\begin{array}{ll}(1-\alpha)(y_h - y_l)\epsilon & \forall\epsilon \geq \tilde{\epsilon}\\ (y_h - y_l)\epsilon & \forall\epsilon < \tilde{\epsilon}\end{array}\right. \tag{2}$$

This implies $c = c(\epsilon)$. The expected return of health expenditures therefore not only depends on μ' (the marginal impact on the probability to switch from productivity y_l to y_h) but also on the firm's productivity and related wage policy. On the one hand if $\epsilon < \tilde{\epsilon}$, wages are so low that firms only contact unhealthy workers. The marginal impact of health expenditures on the probability to improve worker's component of productivity from y_l to y_h is definitely given by μ'. On the other hand if $\epsilon \geq \tilde{\epsilon}$ a share α of workers is already in good health. So the net marginal impact on expected productivity is only $(1-\alpha)\mu' < \mu'$.

At this stage, equations (1) and (2) already show that there exists a discontinuity of health expenditures around $\epsilon = \tilde{\epsilon}$. Taking w_h and w_l as given, $\frac{\partial w}{\partial c} = 0$, it comes that $c'(\epsilon) > 0 \;\; \forall\epsilon \in [\underline{\epsilon}, \tilde{\epsilon}[$ and $\forall\epsilon \in [\tilde{\epsilon}, \bar{\epsilon}]$, but $c(\tilde{\epsilon}_-) > c(\tilde{\epsilon})$.[7] This means that in some cases firms with the highest productivities spend less for workers' health than some firms with lower productivities. Accordingly, this also implies that switching from low wage w_l to high wage w_h is not necessarily associated with higher health expenditures. This typically could occur for those who benefit from w_h but who are in firms with productivity above but close to $\tilde{\epsilon}$.[8]

[6] Introducing on-the-job search, Aizawa and Fang (2013) argue that this effect concerns mainly large firms. Indeed, small firms can not retain their workers for a long time and can not benefit from the positive effects of health investment on productivity of the unhealthy workers.

[7] This result is straightforward from (2). Assume in addition $\gamma = 1$, so $\mu(c) = 1 - \exp(-c)$, we get for instance:

$$c = \log\epsilon + \log(y_h - y_l) + \left\{\begin{array}{ll}\log(1-\alpha) & \forall\epsilon \geq \tilde{\epsilon}\\ 0 & \forall\epsilon < \tilde{\epsilon}\end{array}\right.$$

[8] In contrast, if firms were able to observe and discriminate according to health status of the worker, optimal choices would be zero health expenditure for healthy workers and a strictly increasing profile of those expenditures with ϵ for the unhealthy ones.

3 Endogenous reservation wages of the workers

The next step is to determine endogenous reservation wages and to check whether the reservation wage of healthy workers w_h is always higher than the reservation wage of unhealthy workers w_l. Due to asymmetric information issue, we need to distinguish the situation of a worker in poor health according to the firm's productivity: if $\epsilon \geq \tilde{\epsilon}$ this unhealthy worker will indeed earn the same wage as healthy ones, $w_h(\epsilon)$. Conversely if $\epsilon < \tilde{\epsilon}$ employees in those jobs are all in poor health, and earn $w_l(\epsilon)$. We denote $\Gamma(\tilde{\epsilon})$ the probability for an unemployed worker to contact a firm with a productivity component lower than $\tilde{\epsilon}$. We also introduce ψ_i an indicator of health-dependent satisfaction $i = \{l, h\}$, with $\psi_h > \psi_l$.[9]

Actually, for workers in firms with productivity $\epsilon \geq \tilde{\epsilon}$, it is straightforward to see that the optimal wage offer is equal to the lowest accepted wage by workers in good health. As firms do not observe *ex-ante* health status, this is the only strategy that avoids job rejection for sure. The point is therefore that this lowest accepted wage does not depend on health expenditures of the firm since healthy workers already get the highest satisfaction ψ_h and productivity y_h. This implies that there is only one reservation wage, $w_h(\epsilon) = w_h \ \ \forall \epsilon \geq \tilde{\epsilon}$. Let E_h denote the value function for a healthy employed worker and let U_h be the value for a healthy unemployed individual. The latter only accepts the wage offer if $\epsilon \geq \tilde{\epsilon}$. The value functions are given by:

$$\begin{aligned} rE_h &= w^h + \psi_h - \delta\left[E_h - U_h\right] \\ rU_h &= b + \psi_h + \lambda\left[1 - \Gamma(\tilde{\epsilon})\right]\left[E_h - U_h\right] \end{aligned}$$

where λ stands for the contact rate of unemployed workers. It is obvious that the reservation wage $w_h = b$ is the unique solution of $E_h = U_h$.

Then, turning to the workers in poor health, we need to consider the fact that they can earn either w_h or $w_l(\epsilon)$. The latter wage should indeed depend on ϵ through the health expenditure policy of the firm. Value functions for the workers with the low types can then be written as follows:

$$\begin{aligned} rE_l^h(\epsilon) &= w^h + \mu(c(\epsilon))\psi_h + [1 - \mu(c(\epsilon))]\psi_l - \delta\left[E_l^h(\epsilon) - U_l\right] \quad ; \quad \forall \epsilon \geq \tilde{\epsilon} \\ rE_l^l(\epsilon) &= w^l(\epsilon) + \mu(c(\epsilon))\psi_h + [1 - \mu(c(\epsilon))]\psi_l - \delta\left[E_l^l(\epsilon) - U_l\right] \quad ; \quad \forall \epsilon < \tilde{\epsilon} \\ rU_l &= b + \psi_l + \lambda\int_{\tilde{\epsilon}}^{\overline{\epsilon}}\left[E_l^h(x) - U_l\right]d\Gamma(x) + \lambda\int_{\underline{\epsilon}}^{\tilde{\epsilon}}\left[E_l^l(x) - U_l\right]d\Gamma(x) \end{aligned}$$

where E_l^h defines the expected value of unhealthy individuals who work in firms with productivity greater than $\tilde{\epsilon}$, and therefore earn the wage corresponding to the reservation wage of workers in good health. In addition, with a probability $\mu(c)$ such individuals expect to improve their health and related satisfaction. So their value functions depend on the type ϵ of the firm, through the level of health expenditures provided, *i.e.* $c = c(\epsilon)$. Then, E_l^l defines

[9] Here we follow Grossman's seminal model (1972) considering health as a consumption commodity.

the expected value for unhealthy individuals working in firms with productivity $\epsilon \in [\underline{\epsilon}, \tilde{\epsilon}[$. They receive the reservation wage $w_l(\epsilon)$ that depends on productivity. Indeed, the value of being employed is now increasing with the firms' health expenditures, through the probability μ of being healthier. This health investment decision depends on the type of firms, which will influence the wage. Let U_l be the value of unemployment for workers in poor health. The reservation wage $w_l(\epsilon)$ that characterizes the wage policy of firms with productivity $\epsilon < \tilde{\epsilon}$ is the solution of $E_l^l(\epsilon) = U_l \ \ \forall \epsilon$. It is straightforward to see that this reservation wage satisfies:

$$w_l(\epsilon) \ = \ b - \mu(c(\epsilon))(\psi_h - \psi_l) + \lambda \int_{\tilde{\epsilon}}^{\bar{\epsilon}} \left[E_l^h(x) - U_l\right] d\Gamma(x)$$

Furthermore, it comes also that $\int_{\tilde{\epsilon}}^{\bar{\epsilon}} \left[E_l^h(x) - U_l\right] d\Gamma(x) = \mu(c(\epsilon))(\psi_h - \psi_l)\left(\frac{1-\Gamma(\tilde{\epsilon})}{r+\delta+\lambda[1-\Gamma(\tilde{\epsilon})]}\right)$, from which we find:

$$w_l(\epsilon) \ = \ b - \mu(c(\epsilon))(\psi_h - \psi_l)\left(\frac{r+\delta}{r+\delta+\lambda[1-\Gamma(\tilde{\epsilon})]}\right) < w_h = b$$

This means that the wage earned by unhealthy workers is negatively correlated with the firm's health investment. In addition, this relationship is stronger if the employee's valuation of the benefit is high (high value of $\psi_h - \psi_l$).[10] So we find here the standard wage-health insurance trade-off in line with the theory of compensating differentials (Summers, 1989; Gruber and Krueger, 1991).

However, this holds only if the productivity of the firm is lower than the threshold $\tilde{\epsilon}$. If $\epsilon \geq \tilde{\epsilon}$, the unique reservation wage of the workers in good health is offered, because the value functions of these workers no longer depend on health expenditures. This means formally that the wage policy of the firm is characterized by:

$$\begin{cases} \frac{\partial w(\epsilon)}{\partial c} = 0 \ \ ; \ \ \forall \epsilon \geq \tilde{\epsilon} \\ \frac{\partial w(\epsilon)}{\partial c} = -\mu'(c)(\psi_h - \psi_l)\left(\frac{r+\delta}{r+\delta+\lambda[1-\Gamma(\tilde{\epsilon})]}\right) < 0 \ \ ; \ \ \forall \epsilon < \tilde{\epsilon} \end{cases}$$

4 Equilibrium wages and health expenditures

To derive the explicit solution of the equilibrium we need to proceed in two steps. First, we have to find the solution of a system that jointly determines *(i)* the productivity threshold $\tilde{\epsilon}$ of the firm's type below which the wage policy is so low that only unhealthy individuals agree to work within the firm, and *(ii)* the health expenditure of this critical firm's type, denoted by $\tilde{c}$. The corresponding system is given by:

$$\begin{aligned} \alpha\tilde{\epsilon} \ &= \ \frac{\mu(\tilde{c})}{1-\mu(\tilde{c})}\left(\frac{\psi_h - \psi_l}{y_h - y_l}\right)\left(\frac{1}{1+k[1-\Gamma(\tilde{\epsilon})]}\right) \\ 1 \ &= \ \mu'(\tilde{c})(1-\alpha)(y_h - y_l)\tilde{\epsilon} \end{aligned}$$

[10]Note that if $\psi_h = \psi_l$, we would have $w(\epsilon) = b \ \ \forall \epsilon$ and this would imply $\tilde{\epsilon} = \underline{\epsilon}$.

where $k \equiv \lambda/[r+\delta]$. Then, with $\mu(c) \equiv 1-\exp(-\gamma c)$, it should be noticed that this rewrites as:

$$\exp(\gamma\tilde{c}) = \gamma(1-\alpha)(y_h - y_l)\tilde{\epsilon} \iff \tilde{c} = \Phi(\tilde{\epsilon}) \tag{3}$$

$$\frac{1}{1-\exp(-\gamma\tilde{c})} = \gamma\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{\psi_h - \psi_l}{1+k[1-\Gamma(\tilde{\epsilon})]}\right) \iff \tilde{c} = \Psi(\tilde{\epsilon}) \tag{4}$$

with $\Phi(\underline{\epsilon}) = \frac{1}{\gamma}\log[\gamma(1-\alpha)(y_h - y_l)\underline{\epsilon}], \Phi' > 0, \Phi'' < 0$, and $\Psi(\underline{\epsilon}) \equiv f(\psi_h - \psi_l) > 0, \Psi' < 0$. Accordingly, provided that $\psi_h - \psi_l$ satisfies $\Psi(\underline{\epsilon}) > \Phi(\underline{\epsilon})$, there always exists a unique solution for $\{\tilde{c}, \tilde{\epsilon}\}$.

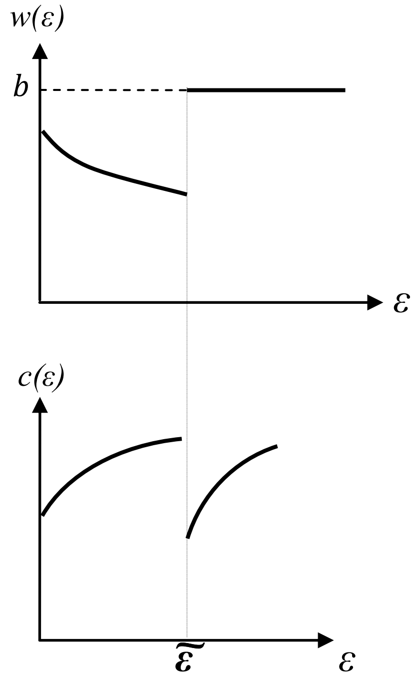
Next, we can characterize wage and health expenditure policies according to firm's productivity with respect to the critical type $\tilde{\epsilon}$; $\{w(\epsilon), c(\epsilon)\}$ satisfies:

$$w(\epsilon) = \begin{cases} b & \forall \epsilon \geq \tilde{\epsilon} \\ b - [1-\exp(-\gamma c(\epsilon))](\psi_h - \psi_l)\left(\frac{r+\delta}{r+\delta+\lambda[1-\Gamma(\tilde{\epsilon})]}\right) & \forall \epsilon < \tilde{\epsilon} \end{cases} \tag{5}$$

$$\exp[\gamma c(\epsilon)] = \begin{cases} (1-\alpha)(y_h - y_l)\epsilon & \forall \epsilon \geq \tilde{\epsilon} \\ (y_h - y_l)\epsilon + (\psi_h - \psi_l)\left(\frac{r+\delta}{r+\delta+\lambda[1-\Gamma(\tilde{\epsilon})]}\right) & \forall \epsilon < \tilde{\epsilon} \end{cases} \tag{6}$$

Figure 1 shows a graphical representation of wage and health expenditure policies of the firms according to productivity ϵ, as defined by equations (3)-(6). This highlights a key implication of the model: due to discontinuity of health expenditures around $\tilde{\epsilon}$, at search equilibrium we do not have a monotonous relationship between firm's type ϵ and health expenditures c, that is: $c'(\epsilon) > 0 \;\; \forall \epsilon < \tilde{\epsilon}, c(\tilde{\epsilon}_{-}) > c(\tilde{\epsilon})$ and $c'(\epsilon) > 0 \;\; \forall \epsilon \geq \tilde{\epsilon}$.

Figure 1: The relationship between wage and firm's health expenditures according to the productivity level

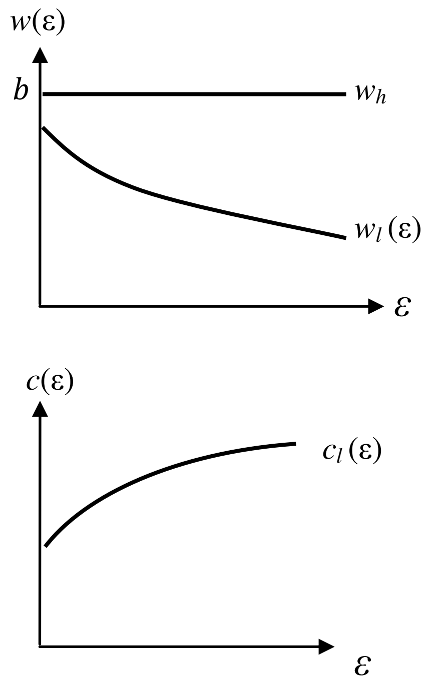


On the one hand, below the productivity threshold $\tilde{\epsilon}$ we obtain a positive relationship between c and ϵ. In turn, this leads wage and health insurance to be negatively related, as predicted by the theory of compensating differentials. As the productivity is rising, employers have some incentives to increase health expenditures. Firms indeed do not observe *ex ante* the health status of workers and the marginal gain from improving health of unhealthy workers, *i.e.* $(y_h - y_l)\epsilon$, is increasing with ϵ. We refer to this channel as a productivity effect.

On the other hand, if the productivity exceeds $\tilde{\epsilon}$, the firm attracts healthy workers who do not value the health insurance. High wages attract healthier workers, which reduces therefore the value of investing in worker's health; this relates to an adverse selection effect. This explains the discontinuity around $\tilde{\epsilon}$ where $c(\tilde{\epsilon}_-) > c(\tilde{\epsilon})$. Nevertheless, as high productivity firms also hire unhealthy workers, the productivity effect remains, so $c(\epsilon)$ is increasing over the interval $[\tilde{\epsilon}, \bar{\epsilon}]$. All in all, it is unclear whether an increase in firm's productivity from $\epsilon < \tilde{\epsilon}$ to $\epsilon \geq \tilde{\epsilon}$ is associated with higher or lower average health expenditures.

Moreover, it is worth emphasizing that this ambiguity between health expenditure and productivity of the firm relies on adverse selection issue. Figure 2 indeed shows what would be the optimal wages and health investment decision by the employer in the context of perfect information. If the employer knew perfectly the health status of the workers, she would offer to the latter a contract with high wage and no complementary insurance $(c_h(\epsilon) \equiv 0 \ \ \forall \epsilon)$. In turn, for the unhealthy workers, we would have health expenditures as much higher as the productivity of the firm is high $(c_l'(\epsilon) > 0)$.

Figure 2: The perfect information case



5 Conclusion

The main contribution of this paper is to explicitly show that in a context of a search equilibrium with two-sided heterogeneity, the relationship between health insurance provided by the employer and firm's type (productivity) is unclear. We highlight how it relates to adverse selection issue.

One could ask whether this result still holds if we consider a continuum of health status. If workers' health affects the value they place on health investment, we will still obtain the two offsetting effects regarding the health insurance-productivity relationship. Indeed, a high wage policy may attract healthier workers and reduces therefore the employers' incentives to invest in their workers' health. As the productivity effect still remains, given that firms do not know *ex ante* the workers' health, health expenditures could increase or decrease.

It is worth noting that our model does not account for on-the-job search and considers only transitory effects of health investment on health. The introduction of job-to-job mobility implies between-firm competition so employers may have interest to offer a wage higher than the reservation wage. It may make our model less tractable without changing the main mechanism at work: higher wages attract healthier workers which reduces the firms' incentives to invest in health.

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